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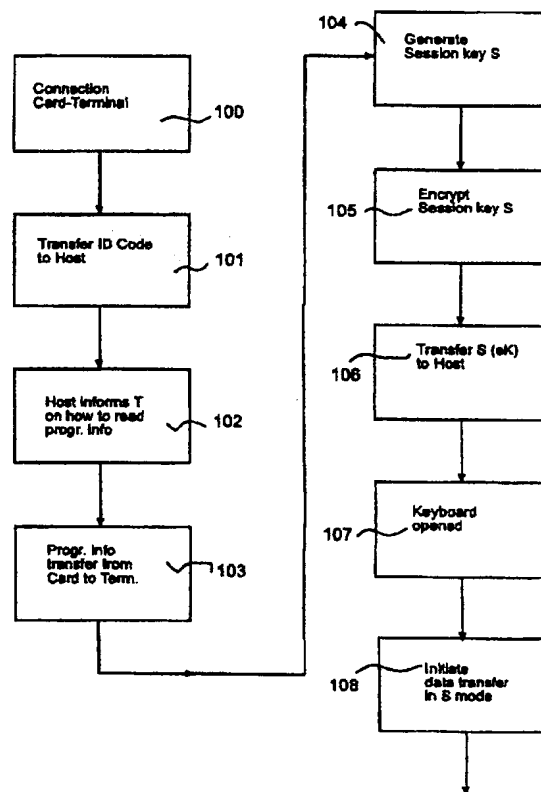
## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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(54) Title: METHOD AND DEVICE FOR DATA COMMUNICATION

## (57) Abstract

A method and a system for use for safe data transfer between a terminal which is controlled by an IC card (1), and a central unit (3), such as a central computer in a bank. The IC card (1) comprises card-specific program information which is used to control the interaction of the card with the terminal (2) in connection with adopting a safe system mode, and card-specific secret information which is used to cryptographically protect data transfers between the terminal (2) and the central unit (3) in a safe system mode. The card specific secret information is stored in such a manner that no read-out of it can be made from the card. The card-specific program information is transferred from the card to the terminal for the purpose of said control.



METHOD AND DEVICE FOR DATA COMMUNICATIONTechnical Field

The present invention relates to a method and a system for data communication between a central unit or  
5 host, such as a central computer in a bank, and a user  
unit comprising an IC card that the user carries and uses  
when he intends to carry out transactions involving  
communications with the host, and a terminal capable of  
communicating with the IC card and the host and acting as  
10 an interconnection link between them.

Background

It is presently known to use data transfer systems  
comprising IC card-controlled terminals and a host. It is  
likewise known to use, in these systems some kind of  
15 secret information to cryptographically protect  
transferred data.

Two principal disadvantages are found in the data  
transfer systems in use today. The first one relates to  
the fact that the terminals contain secret information  
20 which, on account of the physical availability of these  
terminals to the public, may be exposed to violation in  
the sense that an unauthorised person may try to read the  
secret information from the terminal. The second disadvantage is that since present standards on the  
25 configuration of IC cards, with the exception of such  
basic features as signal levels and the like, allow  
considerable degrees of freedom regarding for instance  
the memory addresses to which the data are to be allocated,  
the terminals normally are able to handle one type of  
30 card only.

Object of the Invention

The object of the present invention is to provide a method and a system solving or to a considerable extent eliminating the problems outlined above, thus providing increased flexibility with respect to the cards that may be used in the system and increased safety in the managing of the secret information.

Summary of the Invention

The purpose of the present invention is achieved by a method defined in claim 1 and a system defined in claim 11.

A basic concept of the invention is that at least sensitive data transfers between the user unit and the host are carried out in a separate safe system mode and that program-controlled realisation of the safe system mode is carried out by using card-specific program information contained in the card. The safe system mode means that data transfers are carried out in such a manner that unauthorised persons cannot distort or manipulate transferred data without such interference being discovered. For this purpose, secret information in the user unit and in the host is made use of. The initiation of communication between the card and the terminal is carried out in so-called normal system mode.

Cards used in accordance with the invention contain card-specific program information transferred to and used by the terminal in connection with the establishment of a safe mode.

In accordance with the present invention the "resident" information contents in the terminal is no more extensive than is absolutely necessary. Each card carries program information which is specific to the individual card and which is transferred to the terminal. Since the card-specific program information is transferred to the terminal the latter need not contain "resident" program

information that is specific to each individual card or card type.

This makes it possible to use in the system, cards that are configured in different ways without it being  
5 necessary for the terminal to contain considerable software, and for example several card issuers may use the same set of terminals without it being necessary that the terminal contains, or that the other card issuers have knowledge of, the software that a specific card  
10 issuer uses in order that a safe system mode be adopted.

The system in accordance with the invention allows the terminal to be made both inexpensive and "flexible" in the sense that without difficulties it is possible to adapt the unity card/terminal to include cards that are  
15 configured differently without the terminal having to be changed or be provided with new "resident" program information.

Transfer of card-specific program information from the card to the terminal is effected, in accordance with  
20 a preferred embodiment, under the control of the host the actions of which are based on card-identifying information or a code transferred from the user unit. However, it is obviously possible that this may be effected by the terminal and the card without involving  
25 the host.

Cards used in accordance with the invention likewise contain card-specific secret information which is used to produce cryptographical protection of data transfers and which is stored in such a way that it cannot be read out  
30 from the card.

In accordance with a preferred embodiment the card-specific secret information is used to encrypt (in the widest sense), by means of an algorithm, preferably the  
so-called DES algorithm, a generated session key,  
35 preferably in the form of a random number which is then transferred to the host in encrypted form. This session key is then used to cryptographically protect data

transferred between the user unit and the host in a safe system mode.

The above-mentioned session key is erased in the user unit at the latest the next time contact is established between an IC card and the terminal, although it is possible to effect such erasure, for instance in response to a specific command while contact is still being maintained, because it is desired to begin a new session, or when the contact between the card in question and the terminal is interrupted.

Obviously it is likewise possible to use card-specific secret information as such in order to cryptographically protect data transferred between the host and the user unit in a safe system mode, i.e. that the secret information is used as a cryptographic key, either in an encryption algorithm or in an authentication algorithm.

In accordance with a preferred embodiment, the terminal comprises a keyboard which may be used only in a safe system mode.

In order to protect data transferred on an open line or in another medium accessible to unauthorised persons various different cryptographical techniques are used. A common method is to first encrypt data which are then transferred and finally decrypted. The reverse order is also possible, i.e. to first decrypt data, then transfer them and finally encrypt the transferred data which are then retrieved in cleartext. Both these techniques obviously may be used in connection with the invention. In the case of for instance a random number which is adopted to create an encryption key for an encryption algorithm it is possible to instead transfer the random number in cleartext and to then encrypt/decrypt it and later use the result as an encryption key. Also this technique may be used in connection with the invention, which thus is not limited to use in connection with the

cryptographic technique described herein in detail. Symmetrical as well as asymmetrical encryption systems may be used.

#### Brief Description of the Drawings

- 5 Fig. 1 is a schematic block diagram relating to one embodiment of a system in accordance with the present invention.
- Fig. 2 illustrates a flow chart of measures to be taken in accordance with a preferred embodiment before  
10 initiation of data transfers between the user unit and a host in a safe system mode.
- Fig. 3 illustrates the manner in which an encryption key is generated and encrypted in accordance with one embodiment of the present invention before the  
15 encryption key is transferred to the host.
- Fig. 4 illustrates the authentication of messages (data) in accordance with a preferred embodiment of the present invention.
- Fig. 5 contains a list of the different varieties of  
20 generation of code keys and transfer thereof to the host.
- Figs 6a-6h are flow charts illustrating the varieties listed in Fig. 5.

#### Detailed Description of Embodiments of the Present 25 Invention

In the following a system will be described with reference to Fig. 1 which system is designed for safe data transfers and which comprises a user unit, comprising an IC card 1, a terminal 2, and a central unit  
30 (host) 3.

The IC card 1 comprises card communication means 4 that are placed in contact with terminal communication means 5 to establish a connection for data transfers between the IC card 1 and the terminal 2.

In addition, the IC card 1 comprises first card memory means 9 for storing card-specific program information to be transferred to the terminal 2; second card memory means 10 for storage of card-specific secret information in such a way that it cannot be read out from the card; a memory means 16 for storage of a card-identifying code; and a processor 15 containing required program information to allow execution of the required cryptographic processing, in this case encryption, and generation of a session key before the latter is transferred to the host 3, as will be described further on.

The terminal 2 comprises a terminal communication unit 6 in communication with the central communication unit 7 associated with the host 3, in order to allow data transfers between the host 3 and the user unit, and a key generating means 13, in the form of a random number or pseudo random number generator for generation of a session key to be transferred to the host in an encrypted state and to be used for authentication of messages to be transferred between the user unit and the host 3, as will also be described later on. The terminal 2 comprises storage means 14 to store the session key.

In accordance with another preferred embodiment no key generating means is used in the terminal but the generation of the key instead takes place in the processor 15 in the card.

The terminal 2 and the host 3 in addition comprise control means 8, 18 to control the transfer of the system to the safe system mode which in accordance with the preferred embodiment is considered to have been adopted once the session key has been transferred to the host. In this mode data transfers between the terminal 2 and the host 3 take place in such a manner that data that are being transferred are protected (cryptographic authentication) by means of the session key that has been transferred to the host. In addition, the terminal 2

comprises read-out means 11 for read-out of the card-specific program information in said first card memory means 9, the read-out program information being stored in and used by program executing means 12 in the terminal 2 in order to control interaction between the terminal 2 and the IC card 1.

Fig. 2 illustrates in the form of a flow chart the manner in which the IC card, the terminal and the host cooperate in accordance with one embodiment before data transfer in a safe system mode is initiated, a process to be described in closer detail in the following with reference to Fig. 4.

In step 100, the IC card 1 is inserted in the terminal 2, whereby contact is established between said terminal communication means 5 and said card communication means 4. In step 101, an ID code stored in said memory means 16 is transferred via terminal 2 from the user unit IC card to the host 3. In step 102, on the basis of verification of the card type, i.e. the card configuration, the host 3 informs the terminal 2 on how its read-out means 11 are to proceed to read out the card-specific program information from said first card memory means 9. In accordance with a preferred embodiment, data transferred from the host contains information on the address where the read-out is to begin. In step 103, the card-specific program information is read from card 1 to terminal 2. In step 104, a random number is generated in said key generating means 13, said random number to be used as a session key in a sealing process while using a Message Authentication Algorithm (MAA). In step 105, the session key in the IC card is encrypted in said encryption means 15 using the secret information contained in the second card memory 10 of the IC card 1. In step 106, the session key is transferred in encrypted state to the host 3. Steps 104, 105 and 106 are illustrated in closer detail in Fig. 3. In step 107, a keyboard associated with the terminal 2 is opened for



use. In step 108, data transfer is begun in the now adopted safe system mode.

In the following, the description will be made with reference to Fig. 3. In accordance with the preferred  
5 embodiment a random number is generated in the terminal to be used as a key in an MAA process to authenticate messages (i.e. data) transferred from the user unit to the host and vice versa. This random number is then encrypted in the card in a DES encryption algorithm,  
10 using the secret information (DES key) in said second card memory means 10 (Fig. 1) as the encryption key in order to be transferred in encrypted state (the encrypted random number is designated by eK) via the terminal to the host 3, wherein it is decrypted and used as a session  
15 key in an MAA.

In Fig. 4 is exemplified the manner in which data transfers and authentication of data are carried out in a safe system mode in accordance with the preferred embodiment. The encrypted random number eK, having been  
20 transferred from the user unit, is decrypted in the host by means of a key stored in the host, said key depending on the card that is being used and being identical with the one in said card. The decrypted random number is then used as an MAA key together with a message to be  
25 transferred to the user unit and a message serial number, in an MAA in order to generate a cryptographic check sum, Message Authentication Code (MAC), which is added to and used to authenticate the message. The MAC will have a different appearance in successive messages during one  
30 and the same session (also when their contents are the same, since they have received different serial numbers). Thus, a flow of data is transferred, containing the message, the serial number, in cleartext, and a MAC.

In the user unit an MAA check is carried out to  
35 verify the message received while using the MAA key in the terminal, i.e. the random number, or in other words, a check to verify whether the message has been

manipulated on its way from the host to the user unit. The check comprises a corresponding computation of a MAC and a comparison thereof with the MAC received together with the message, to determine coincidence.

5        When the user unit is to transfer a response message to the host one proceeds in a corresponding manner, i.e. on the basis of the random number, the response, and the serial number transferred from the host a new MAC is computed, which is added to the flow of data formed by  
10    the response from the user unit to the host and the latest serial number transferred from the host. The host then performs an MAA check of the transferred response in order to check that the response has not been manipulated on its way between the user unit and the host. Further  
15    message transfers may then be carried out in the same way.

Fig. 5 is an account of a number of possible modifications 1-8 of random number generation and protection of random numbers that may be used in connection with  
20    the present invention. Four cases (1,3,5,6) are shown in which the random number used as a session key is generated in the terminal and four cases (2,4,7,8) wherein the random number is generated in the card. In addition, four different varieties are shown of the forms in which the  
25    corresponding session key is used for cryptographic protection respectively is transferred to the host.

Figs 6a-6h show the eight various cases accounted for in Fig. 5 in more detail. The various steps illustrated for each case are indicated by numeral references  
30    placed inside white rectangular boxes. Each Figure illustrates the situation occurring when a user has inserted his card in the terminal and the system is about to accomplish a safe mode. It appears from the Figures that steps S1-S5 are identical for all eight varieties.  
35    In step S1, the central unit (Host) commands the terminal (Terminal) to read out the identification number of the card to verify whether the card is associated with the

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host in question and, when the verification is positive, to supply the encryption key which is associated with the card and which is to be used in the host to encrypt or decrypt the random number (session key), depending on in which form the key has been transferred to the host. In step S2, the terminal transfers the read-out card number to the host. In all eight cases, the host makes sure that the card has been issued by the user of the host, whereupon in step S3 it orders the terminal to begin to assume a safe mode. In steps S4 and S5 the terminal executed the program sequence that is its resident program information, i.e. to read and fetch the card-specific program information from a file (SMIB) in the card. The rest of the steps to be executed in order for a safe mode to be assumed is governed by the contents of SMIB, i.e. the card-specific program information. This shows that a comparatively simple and thus inexpensive terminal (in principle capable only of reading out a file from an IC card), when used in a system in accordance with the present invention, may achieve an astonishing degree of flexibility with respect to its ability to interact with cards that are configured in different ways. The first case illustrated is the one shown in Fig. 3, i.e. the random number to be used as a session key is generated in the terminal and is encrypted in the card, in step S6 before being transferred to and stored in the terminal in step S7, the terminal finally, in step S8, sending the encrypted random number to the host, whereupon data transfer in safe system mode may be started in accordance with Fig. 4.

In accordance with the second case illustrated the following steps are performed, in addition to steps S1-S5 already described, viz.: in step S62 the terminal orders (in accordance with the contents of the corresponding SMIB) the card to generate a random number; the card generates and sends a random number to the terminal wherein it is stored, in step S72; in step S82 the termi-

nal orders the card to encrypt the generated random number; the card encrypts the random number and transmits it in encrypted state to the terminal; in step S102, finally, the terminal transmits the encrypted random  
5 number to the host, whereupon data transfer in safe system mode may start in accordance with Fig. 4.

In the third case illustrated, the following steps are executed in addition to steps S1-S5 already described, viz.: in step S63 the terminal generates and  
10 stores a random number and orders the card to decrypt the random number: in step S73 the decrypted random number is transferred to the terminal; and in step S83 the decrypted random number is transferred to the host. When the random number (session key) reaches the host it should  
15 not be decrypted before use but be encrypted in order to provide the key in cleartext, and otherwise data transfers are commenced in a safe system mode in same manner as illustrated in Fig. 4.

In the fourth case illustrated the following steps are executed, in addition to steps S1-S5 already described, viz.: in step S64 the card is ordered to generate a  
20 random number; in step 74 this random number is transferred to and stored in the terminal; in step S84 the terminal orders the card to decrypt the random number; in step  
25 S94 the card sends the decrypted random number to the terminal; and in step S104 the decrypted random number is sent to Host. When the random number (session key) reaches the host it should not be decrypted before use but be encrypted to provide the key in cleartext and  
30 otherwise the data transfer in a safe system mode commences in the same manner as illustrated in Fig. 4.

In the fifth case illustrated the following steps are executed, in addition to steps S1-S5 already  
described, viz.: the terminal generates a random number  
35 which is transmitted in step S85 to the host in cleartext and which in step S65 is encrypted by the card; in step S75 the encrypted random number is transferred to and

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stored in the terminal. Because there is an encrypted session key in the terminal and because the session key has been transferred to Host in cleartext it is necessary, in order to establish data transfer in safe system mode, to encrypt the session key in Host before it can be used.

The sixth case illustrated is distinguished from the fifth case only in the respect that whenever encrypting is effected in the fifth case decrypting now is to be performed.

In the seventh case illustrated the following steps are executed, in addition to steps S1-S5 already described, viz.: in step S67 the terminal orders the card to generate a random number which in step S77 is transferred to the terminal; in step S107 this random number is transferred in cleartext to the terminal and in step S87 the card encrypts the random number; in step S97, finally, the encrypted random number is transferred to and stored in the terminal. Because there is an encrypted session key in the terminal and because the session key has been transferred to Host in clear text it is necessary, in order to establish data transfer in safe system mode, to encrypt the session key in Host before it may be used.

The eighth case illustrated is distinguished from the seventh one only in the respect that whenever encrypting is effected in the seventh case decrypting now is to be performed.

One example of a set of the card-specific program information being transferred from the card to the terminal and producing the generation of a session key and transfer thereof to the host in accordance with variety 1 in Fig. 5 (Fig. 6a) may contain the following sequence of commands; OPEN (open up the file in the card containing the card-specific secret information, allowing it to be used as an encryption key in an encryption algorithm), RANDOM (generate a random number in the key-generating

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means 13 of the terminal in accordance with the instructions contained in the command and storage of said number in the terminal storing means 14), CRYPT (read over the random number to the card and encrypt the random number in the card using a conventional encryption algorithm defined in and executed by the processor 15, and the encryption key), READ (read out the encrypted random number to the terminal) and TRANS (transfer the encrypted random number to host).

10       It should be understood that the commands and functions defined are only of an exemplifying nature and that they may be implemented in a large number of different ways and in a large number of different program languages. The methods of implementation of the functions  
15       used in the embodiments in accordance with the present invention in program code must be considered self-evident to those skilled in the art when reading the present invention and therefore they will not be described in more detail herein.

## CLAIMS

1. A method of transferring data between a user unit  
5 comprising a terminal and an IC card which is placed in  
communication with the terminal, and a central unit, such  
as a central computer located at a producer of services,  
preferably a bank, secret information being used in the  
user unit and the central unit to protect data  
10 transferred between said units, c h a r a c t e r i s e d  
in that the user unit is made to operate in a safe system  
mode involving safe data transfer between the user unit  
and the central unit in the sense that unauthorised  
persons cannot gain knowledge of the transferred data  
15 and/or that it is possible to verify whether transferred  
data have been distorted or been replaced during the  
transfer, in that card-specific program information in  
the card is used to control the terminal as the latter  
interacts with the card in connection with the user unit  
20 being made to operate in a safe system mode, the card-  
specific program information being transferred to the  
terminal to be utilised in connection with said control,  
and in that safe data transfers are effected while making  
use of card-specific secret information in the IC card,  
25 the use of the card-specific secret information for  
cryptographic protection being effected in such a manner  
that the card-specific secret information never leaves  
the card.

2. A method as claimed in claim 1, wherein  
30 operations initially being carried out in a normal system  
mode in which communication is established between the  
terminal and the card and in which the card-specific  
program information is transferred to the terminal.

3. A method as claimed in any one of claims 1-2,  
35 wherein a card-identifying code being transferred from  
the user unit to the central unit, on the basis of which  
code said central unit instructs the user unit on the

15

manner to be adopted for the transfer of the card-specific program information from the card to the terminal.

4. A method as claimed in any one of claims 1-2,  
5 wherein the transfer of the card-specific program information is carried out on the basis of information contained in the terminal and/or the IC card before communication is established therebetween.

5. A method as claimed in any one of claims 1-4,  
10 wherein a session key is created in the user unit for use in the transfer of data in a safe system mode, said session key being encrypted or decrypted in the IC card, and wherein said session key is transferred to the central unit in an encrypted or decrypted form.

15 6. A method as claimed in any one of claims 1-4, wherein a session key is created in the user unit, said session key being transferred to the central processing unit in cleartext, whereupon said session key is encrypted or decrypted in the central processing unit and the IC  
20 card, to be used in an encrypted or decrypted form in the transfer of data in a safe system mode.

7. A method as claimed in claim 5 or 6, wherein the session key is a random number which preferably is generated in the terminal.

25 8. A method as claimed in any one of claims 5-7, wherein the session key in the user unit is erased as soon as connection between the card and the terminal is interrupted.

9. A method as claimed in any one of claims 5-7,  
30 wherein the session key in the user unit is erased as soon as a new connection is established between the terminal and an IC card.

10. A method as claimed in any one of the preceding claims, wherein input of information via a keyboard associated with the terminal may be effected only in a safe  
35 system-operational mode.



11. A system for transfer of data, comprising a user unit (1, 2) having an IC card (1) and a terminal (2), and a central unit (3), said card (1) comprising card communication means (4) for communication with the terminal (2), the terminal (2) comprising terminal communication means (5) for communication with the card (1), and a terminal communication unit (6) for communication with the central unit (3), said central unit (3) comprising a central communication unit (7) for communication with the terminal (2), and the user unit (1, 2) and the central processing unit (3) comprising secret information that is used to cryptographically protect data transfers between said units, characterised in that the IC card (1) comprises first card memory means (9) for storage of card-specific program information, and second card memory means (10) for storage of card-specific secret information which is used to cryptographically protect data transferred between the user unit and the central unit (3) in a safe system mode, said second card memory means (10) being configured in such a manner that said secret information cannot be read out from the card (1), that the terminal (2) comprises terminal read-out means (11) for reading the contents of said first card memory means (9) and program executing means (12) arranged, while utilising the read-out card-specific program information, to control the interaction between the terminal (2) and the IC card (1) in order to establish the safe system mode.
12. A system as claimed in claim 11, wherein the user unit comprising key generating means (13) arranged to generate a session key, and storage means (14) for storing such a session key, and wherein the IC card (1) comprises processing means (15) arranged to cryptographically protect the session key which said terminal communication unit (6) is arranged to transfer to the central unit.

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13. A system as claimed in claim 12, wherein said key generating means (13) being a random number generator or a pseudo random number generator.

14. A system as claimed in claim 12 or 13, wherein  
5 said key generating means (13) are arranged in the terminal (2).

15. A system as claimed in claim 12 or 13, wherein said key generating means forms an integrated part of said processing means (15).

10 16. A system as claimed in any one of claims 12-15, wherein the user unit is arranged to erase the session key in the user unit as soon as connection between said card communication means (4) and said terminal communication means (5) is interrupted.

15 17. A system as claimed in any one of claims 12-15, wherein said user unit is arranged to erase the session key in the user unit as soon as new connection is established between said card communication means (4) and said terminal communication means (5).

20 18. A system as claimed in any one of claims 11-17, wherein the IC card (1) comprises memory means (16) for storage of card-identifying information or a card-identifying code arranged to be transferred to the central unit (3), said central unit being arranged, while being guided  
25 by said code or information, to instruct the user unit (1, 2) of the manner in which the contents of said first card memory means (9) are to be read out.

19. A system as claimed in any one of claims 11-18, wherein the user unit comprises a keyboard for input of  
30 data into the system, said keyboard being arranged to be operative only when the system is in a safe system mode.

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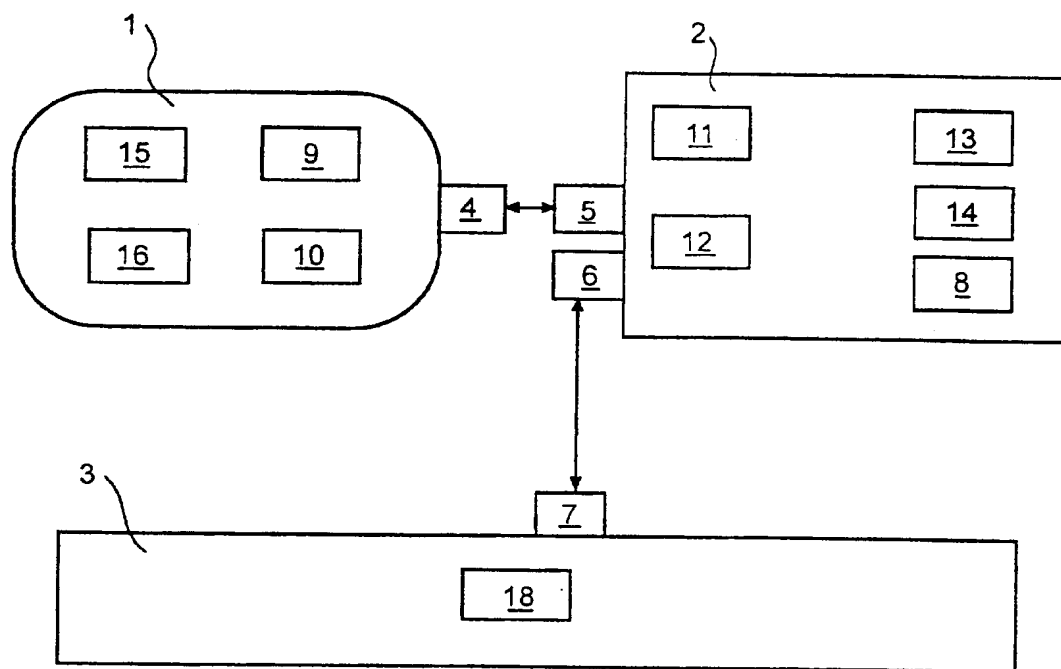


Fig. 1

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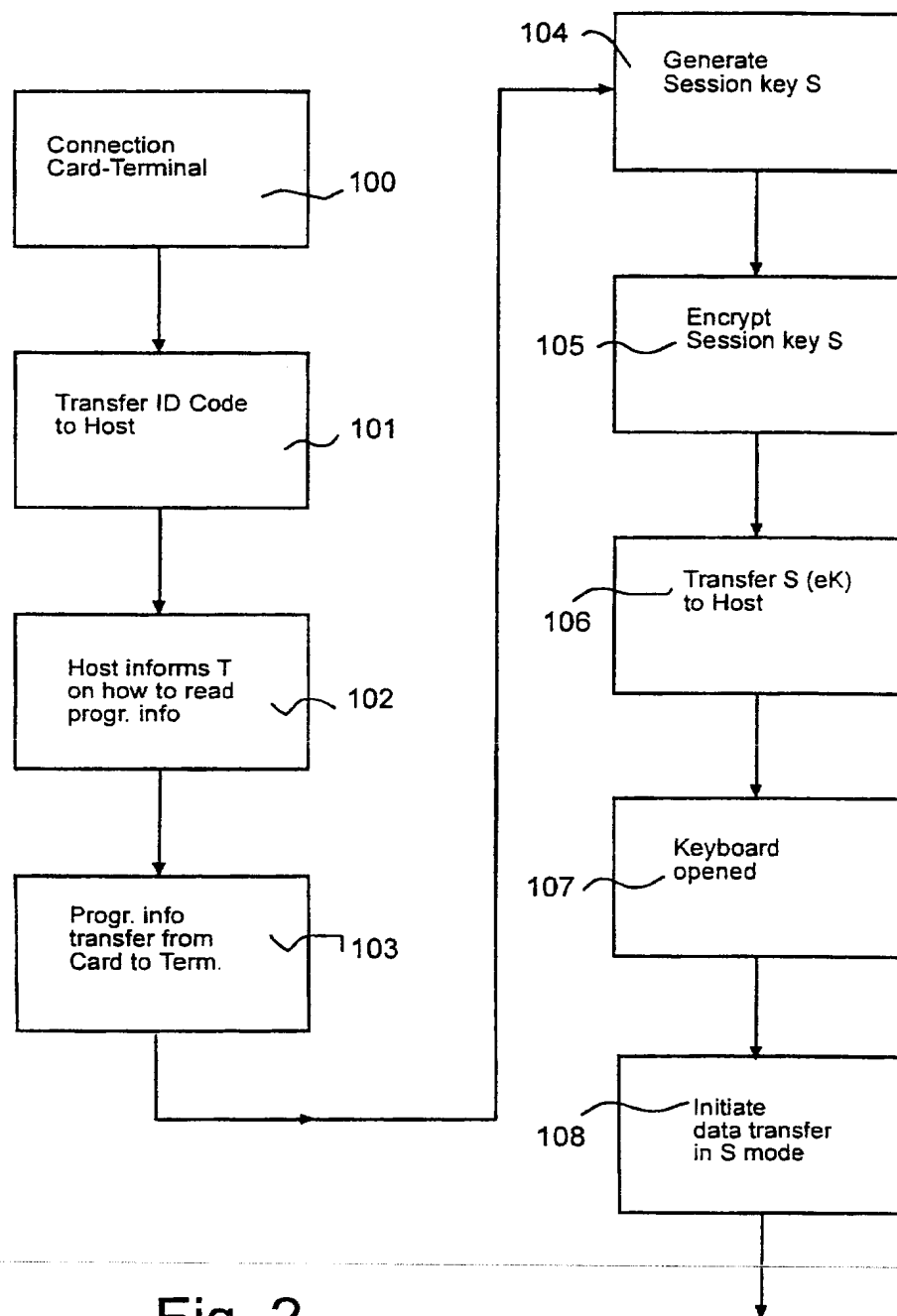


Fig. 2

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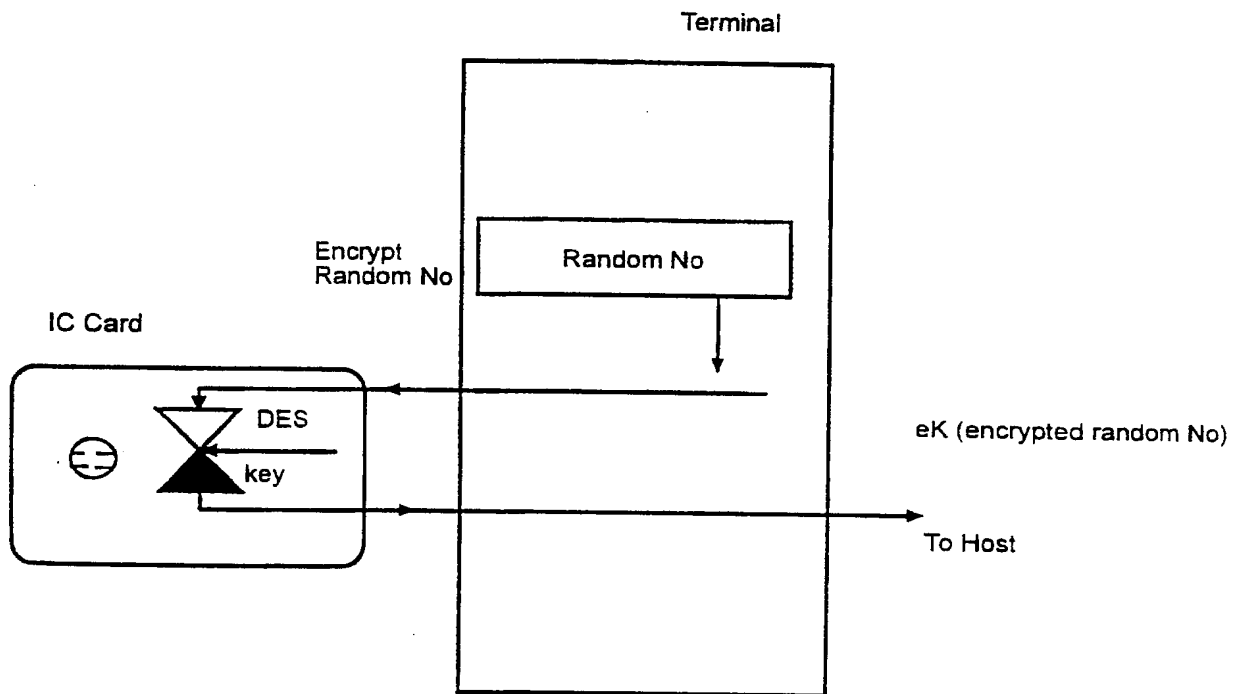


Fig. 3

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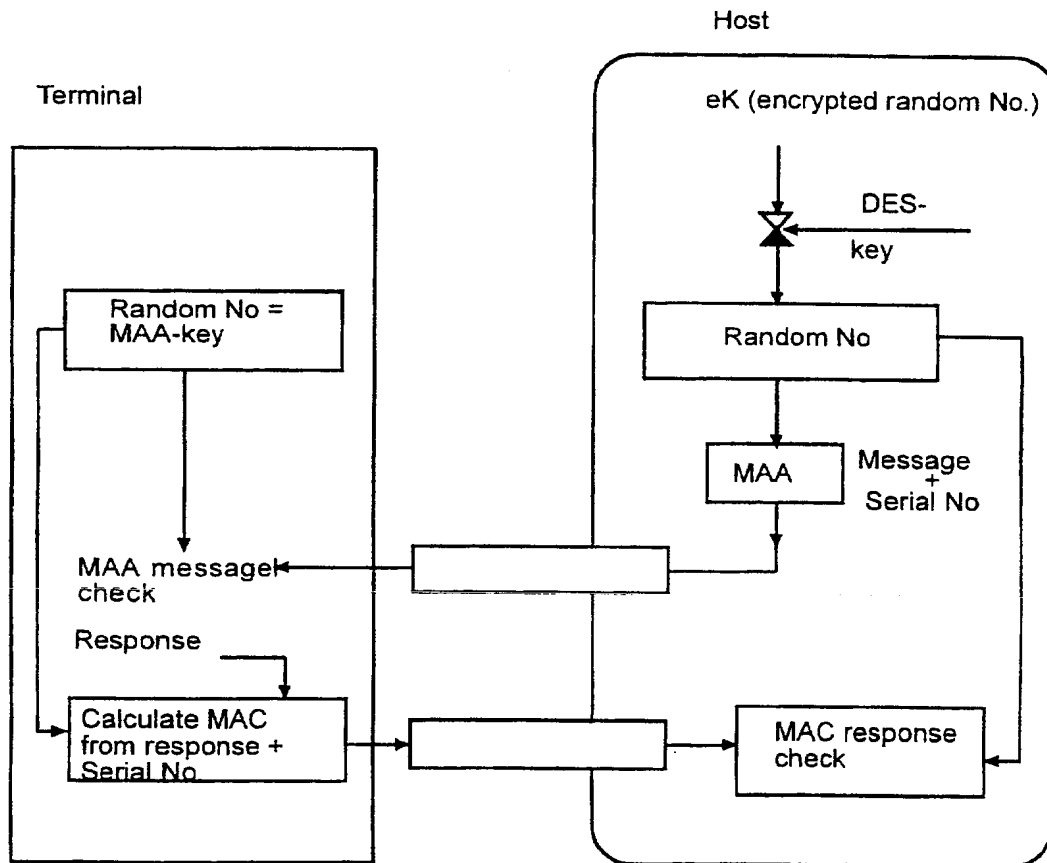


Fig. 4

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Variety	Generate Ranom No in	Store in Terminal and use Random No	Send Random No to Host	Prior to use in Host. received value to be
1	Terminal	In Cleartext	Encrypted	Decrypted
2	Card	In Cleartext	Encrypted	Decrypted
3	Terminal	In Cleartext	Decrypted	Encrypted
4	Card	In Cleartext	Decrypted	Encrypted
5	Terminal	Encrypted	In Cleartext	Encrypted
6	Terminal	Decrypted	In Cleartext	Decrypted
7	Card	Encrypted	In Cleartext	Encrypted
8	Card	Decrypted	In Cleartext	Decrypted

Fig. 5

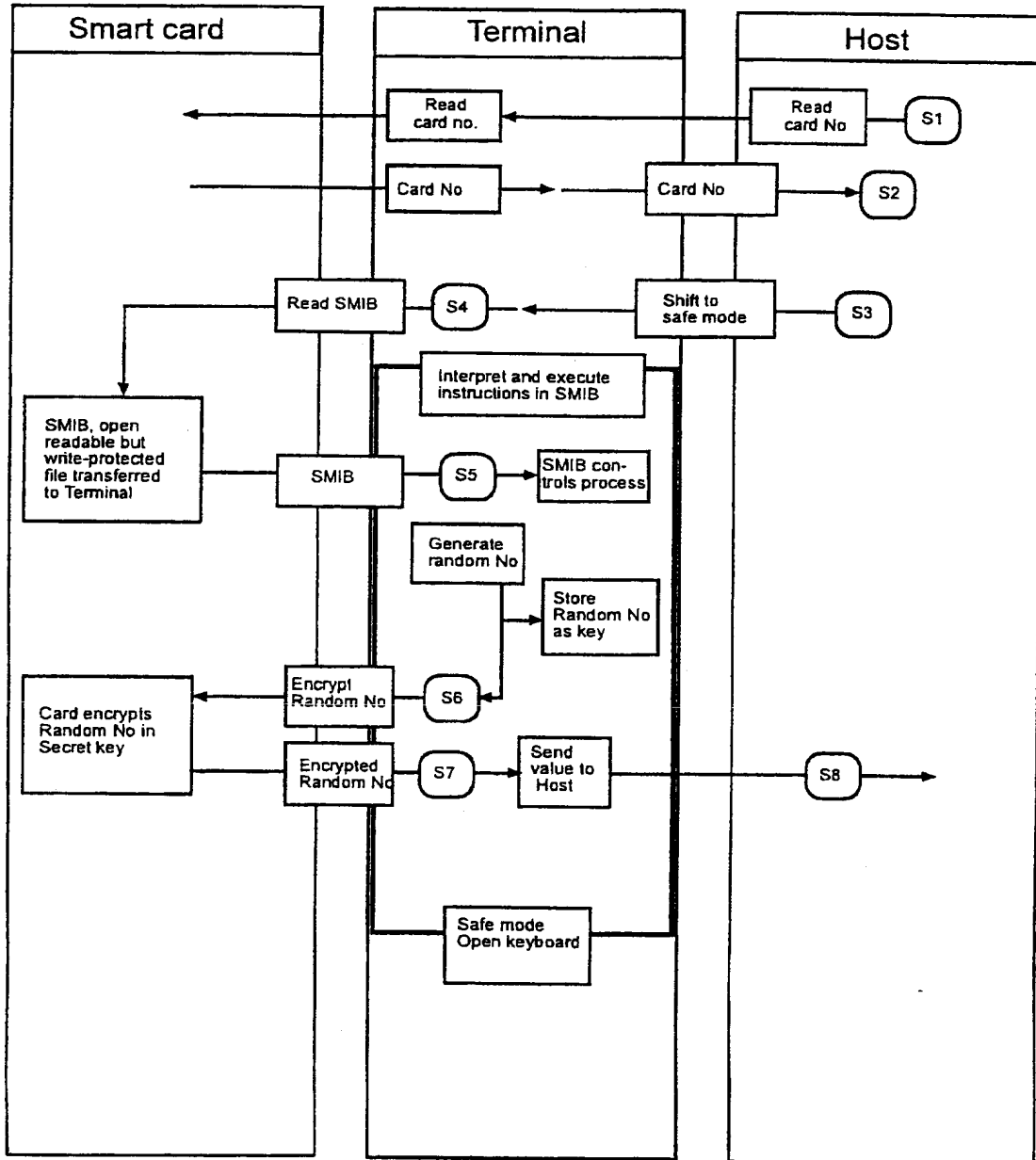


Fig. 6a



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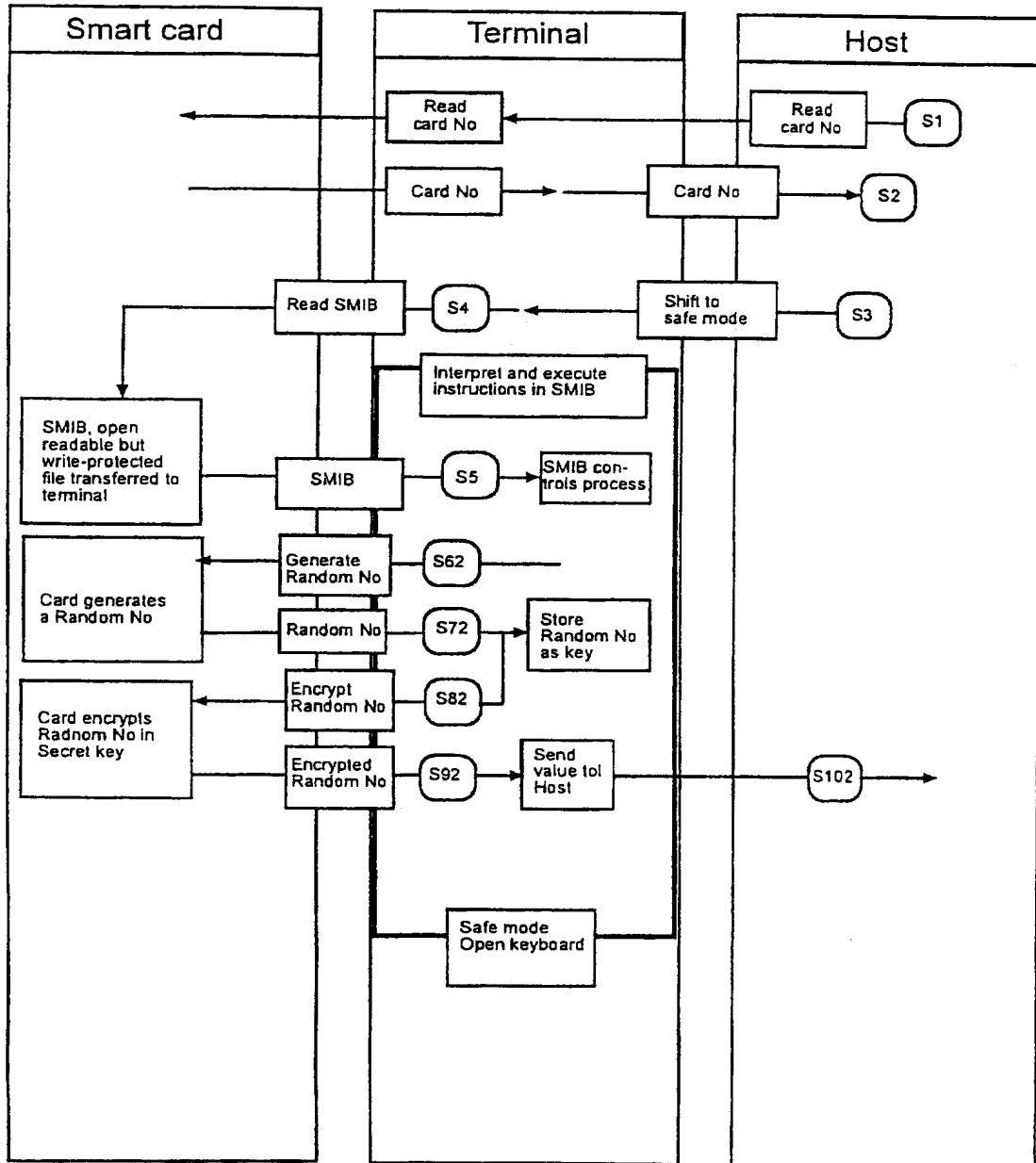


Fig. 6b

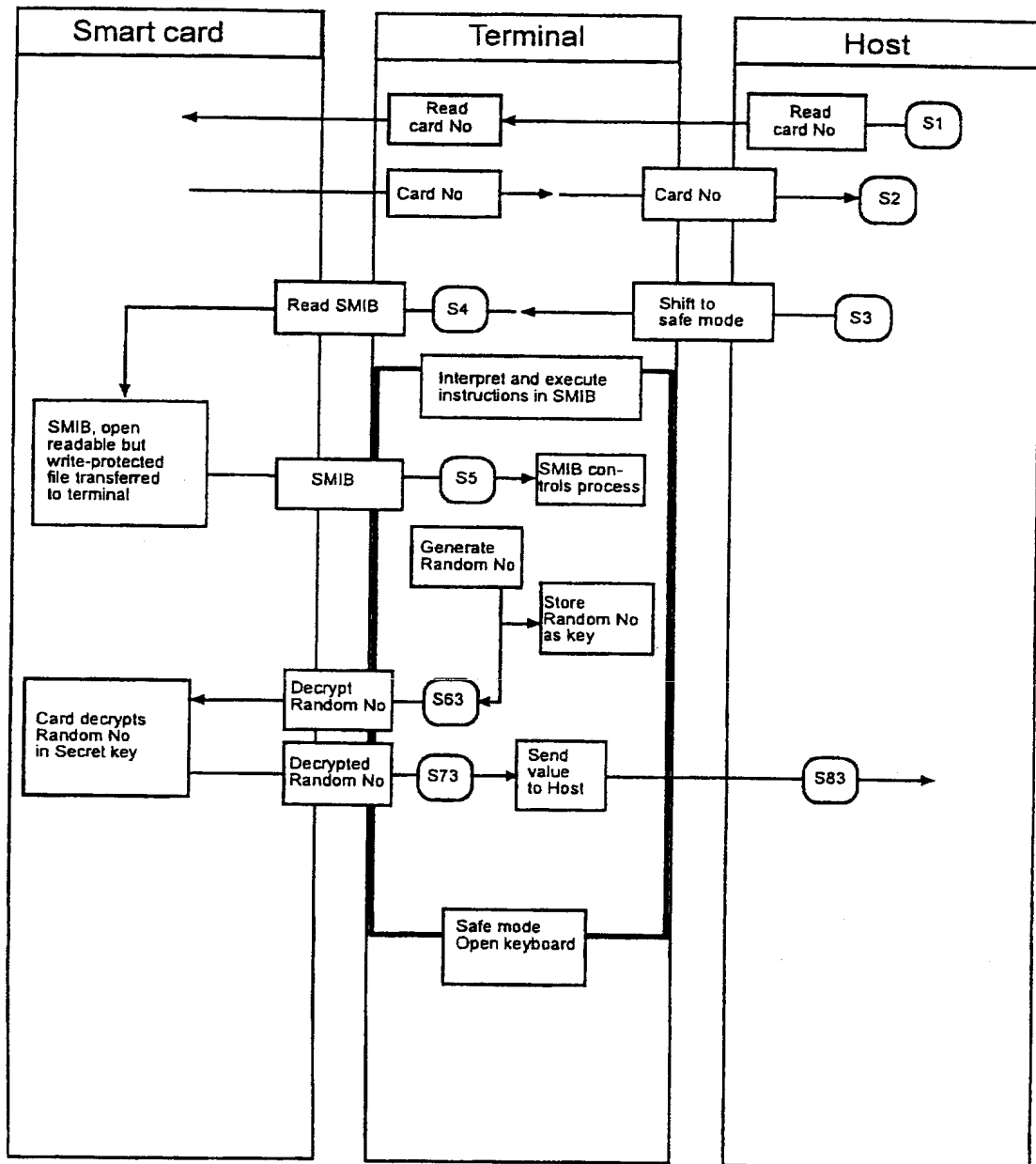


Fig. 6c

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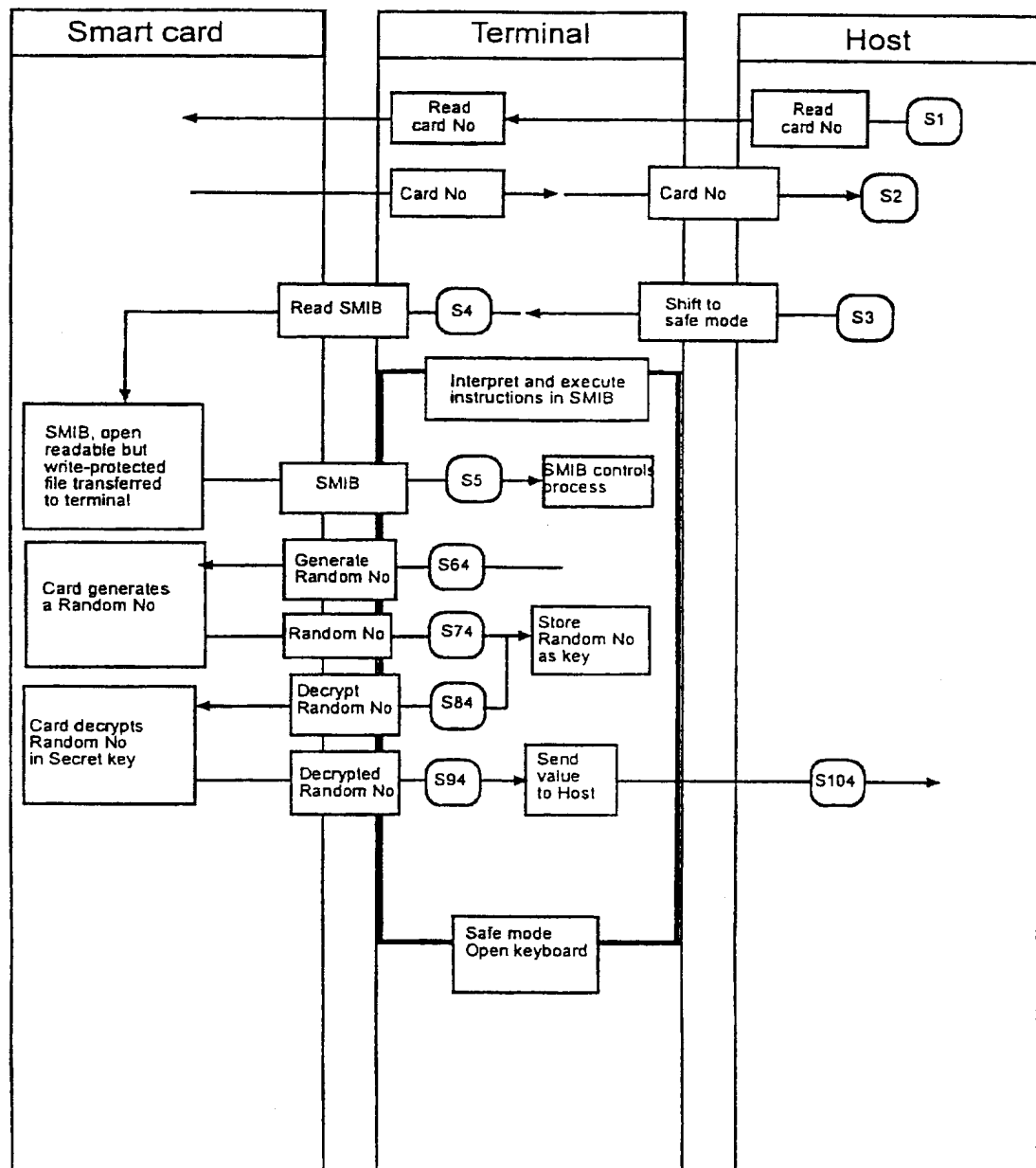


Fig. 6d

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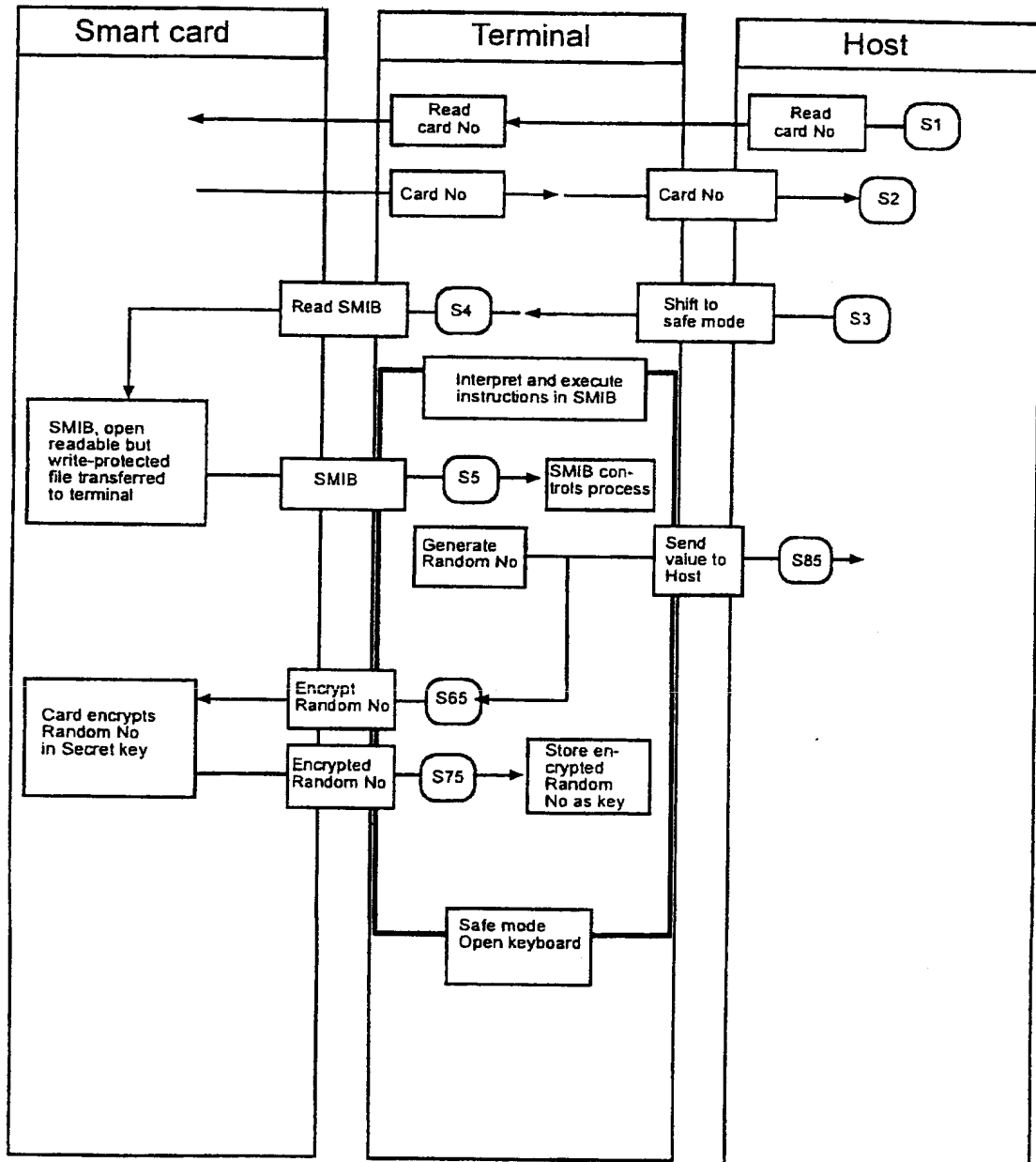


Fig. 6e

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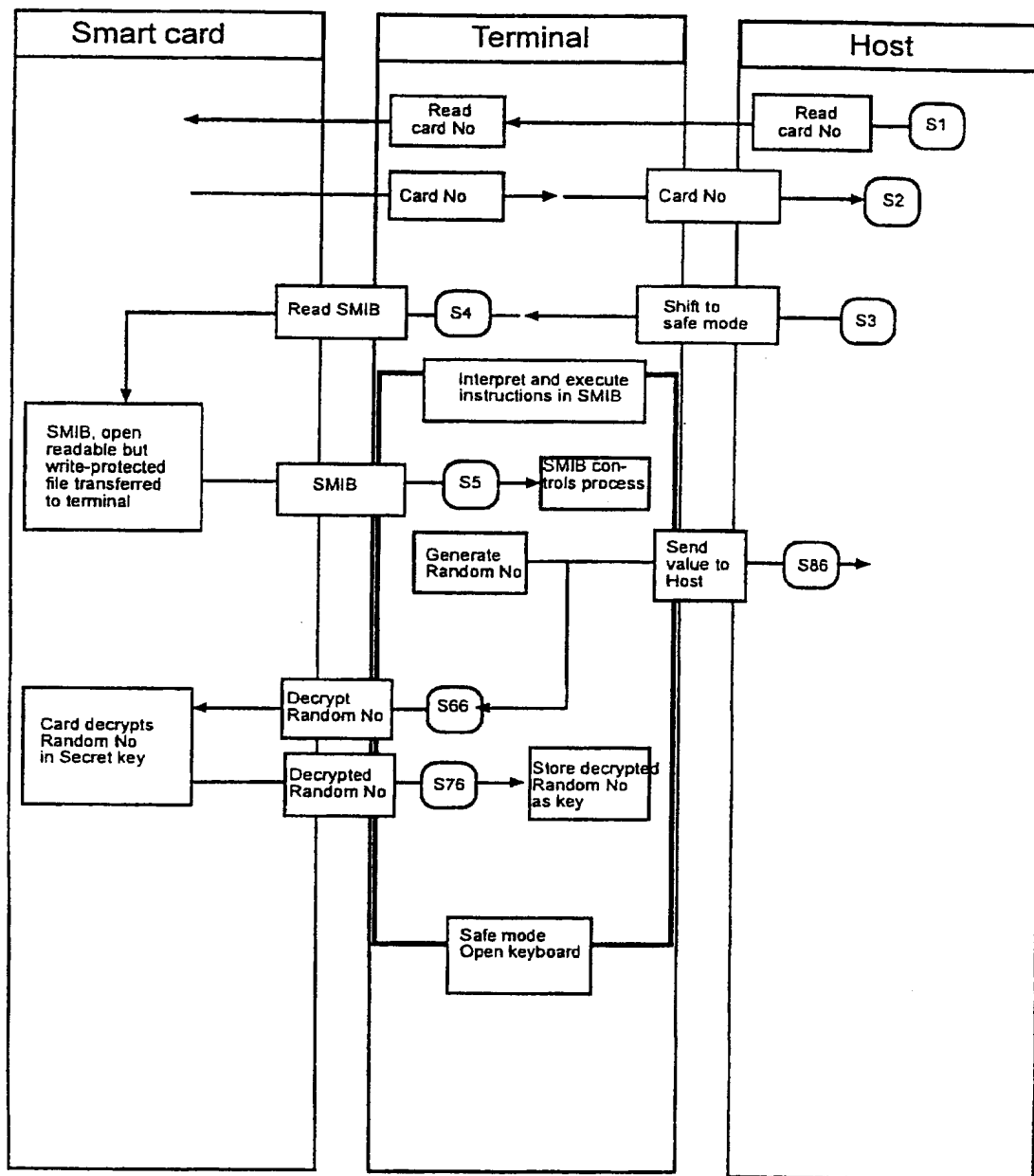


Fig. 6f

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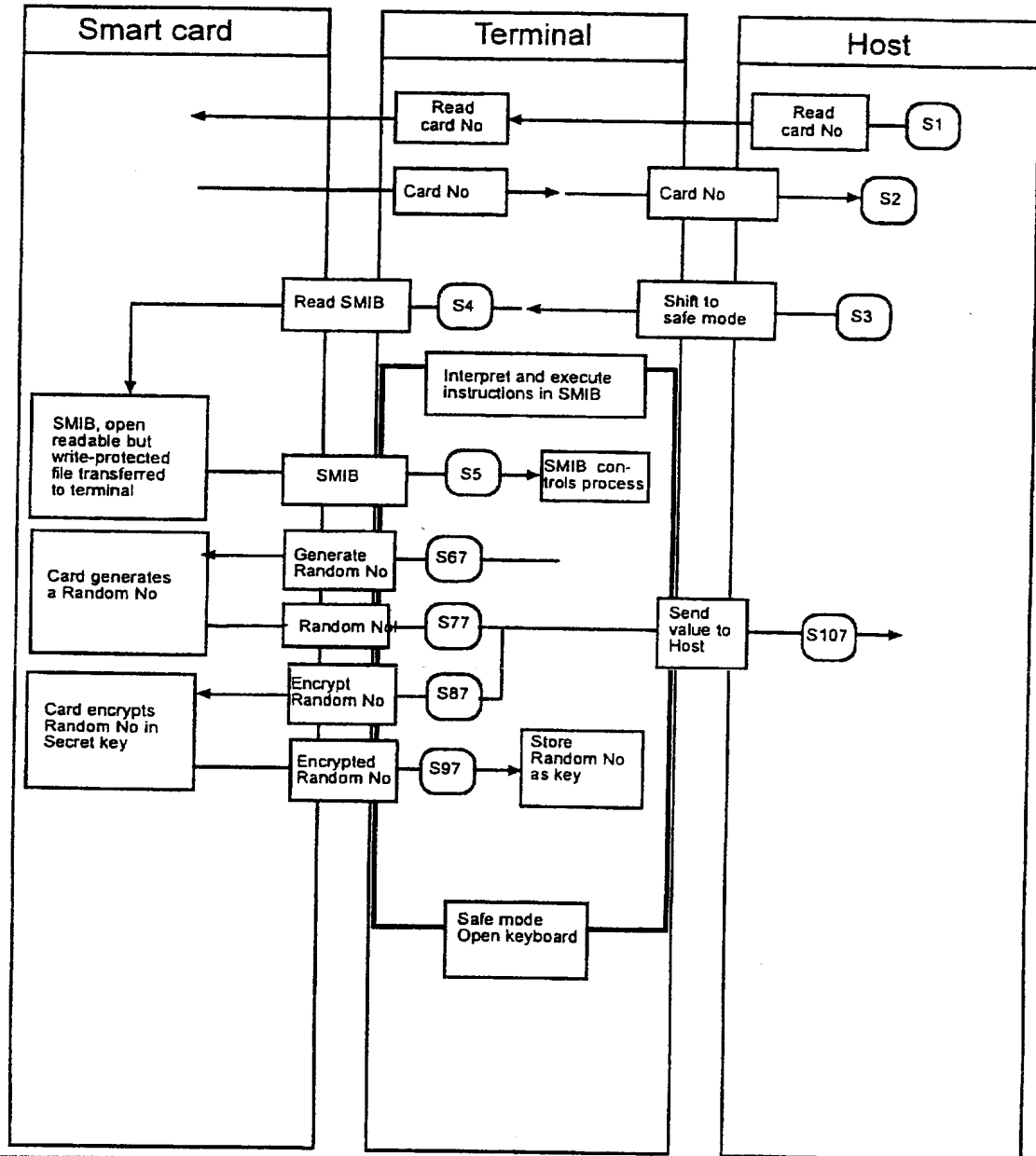


Fig. 6g

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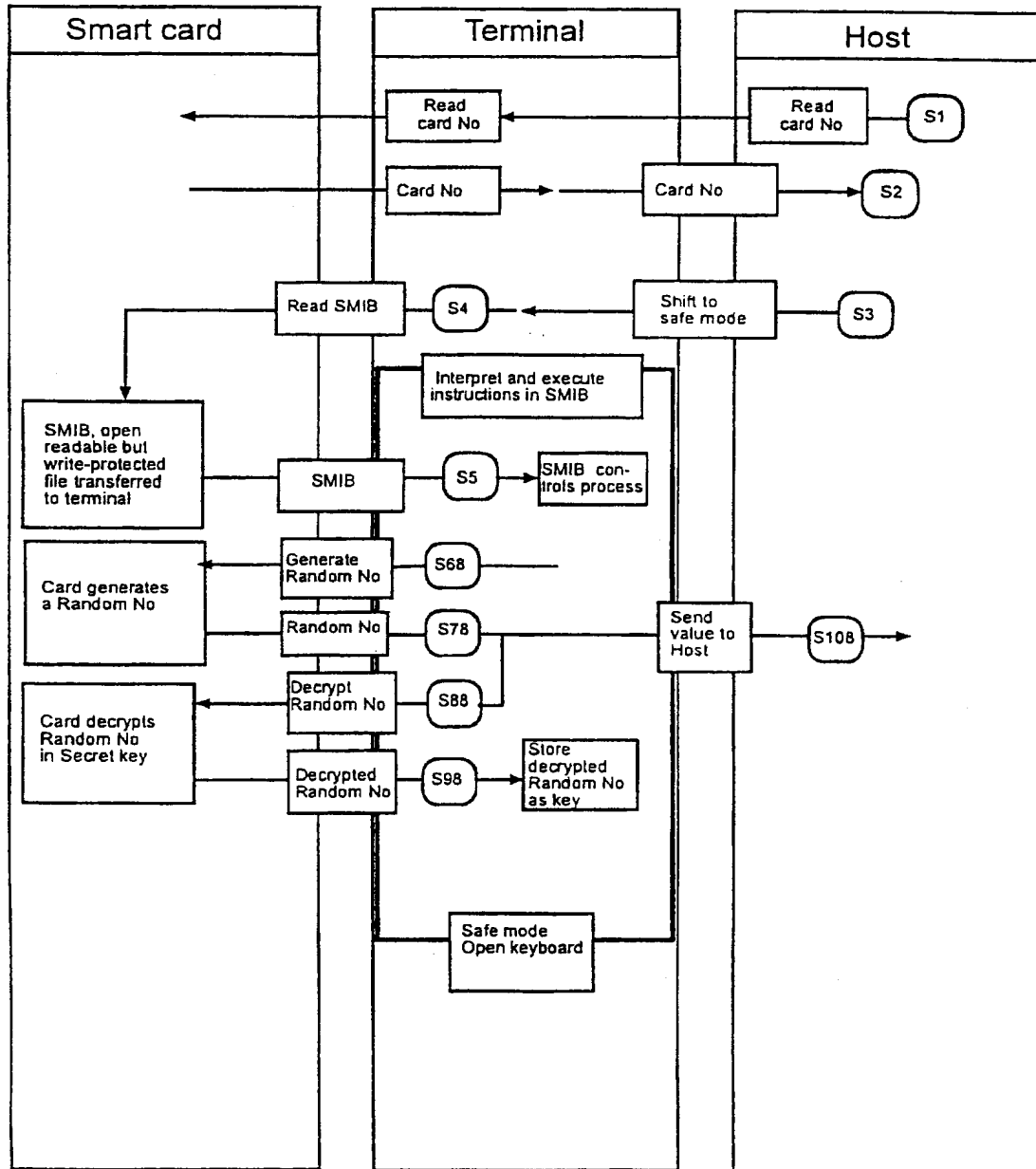


Fig. 6h

